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DISEASE DETECTION SURVEY
Air Pollution

Gila National Forest
Silver City, New Mexico

By
Robert C. Loomis
Forest Service, USDA
Division of Timber Management
517 Gold Avenue, SW
Albuquerque, New Mexico 87101

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In September 1971, Robert Loomis, plant pathologist in the Forest Service Insect and Disease Branch, and Bud Figart, Timber Staff Officer, Gila National Forest, examined trees and associated plants on selected areas of the Gila National Forest, New Mexico. The purpose of the survey was to determine if acute injury had occurred to forest vegetation from SO_2 emitted by the Kennecott smelter located at Hurley, New Mexico. No symptoms of acute SO_2 injury were found; however, chlorotic foliage, a symptom of several plant disorders including chronic SO_2 injury, was noted. The significance of this symptom has yet to be determined because similar symptoms were also found in areas far removed from sources of SO_2.

Method.--A detection system, consisting of six sulfation plate stations and seven vegetative observation areas, was established during the period of October 1970-June 1971. These sulfation plate stations and observation areas are located on the Silver City, Mimbres, Wilderness, and Glenwood Ranger Districts of the Gila National Forest (Figures 1, 2, and 3). Where possible, the sulfation plate stations and observation areas were established together in species type and location most susceptible to SO_2 injury. By locating the sulfation plates and observation areas together, we may be able to determine if there is a relationship between sulfation rate and the presence or absence of plant injury. By finding areas most susceptible to SO_2 injury, the detection system is made more sensitive to possible SO_2 injury.

Considerations for establishing observation areas include:

1. Presence of a variety of trees and associated plants growing in the area. One phase in evaluating possible SO_2 injury to plants

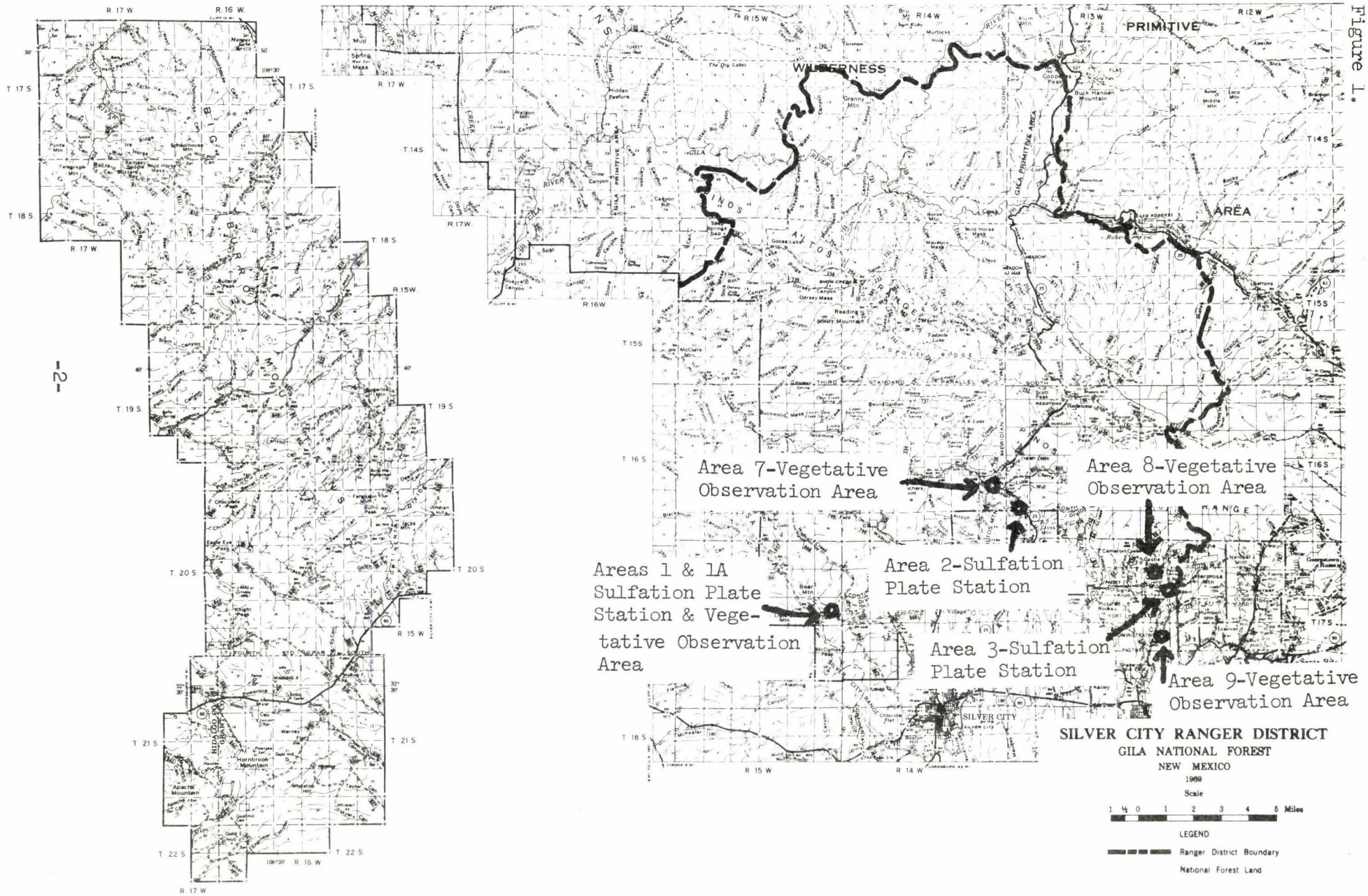

Area 7-Vegetative Observation Area
Area 8-Vegetative Observation Area
Area 2-Sulfation Plate Station
Areas 1 & 1A Sulfation Plate Station & Vegetative Observation Area
Area 3-Sulfation Plate Station
Area 9-Vegetative Observation Area
SILVER CITY RANGER DISTRICT
GILA NATIONAL FOREST
NEW MEXICO
1969
Scale
1 ½ 0 1 2 3 4 5 Miles
LEGEND
Ranger District Boundary
National Forest Land
WILDERNESS
PRIMITIVE AREA
SILVER CITY

Figure 1.

Figure 2.

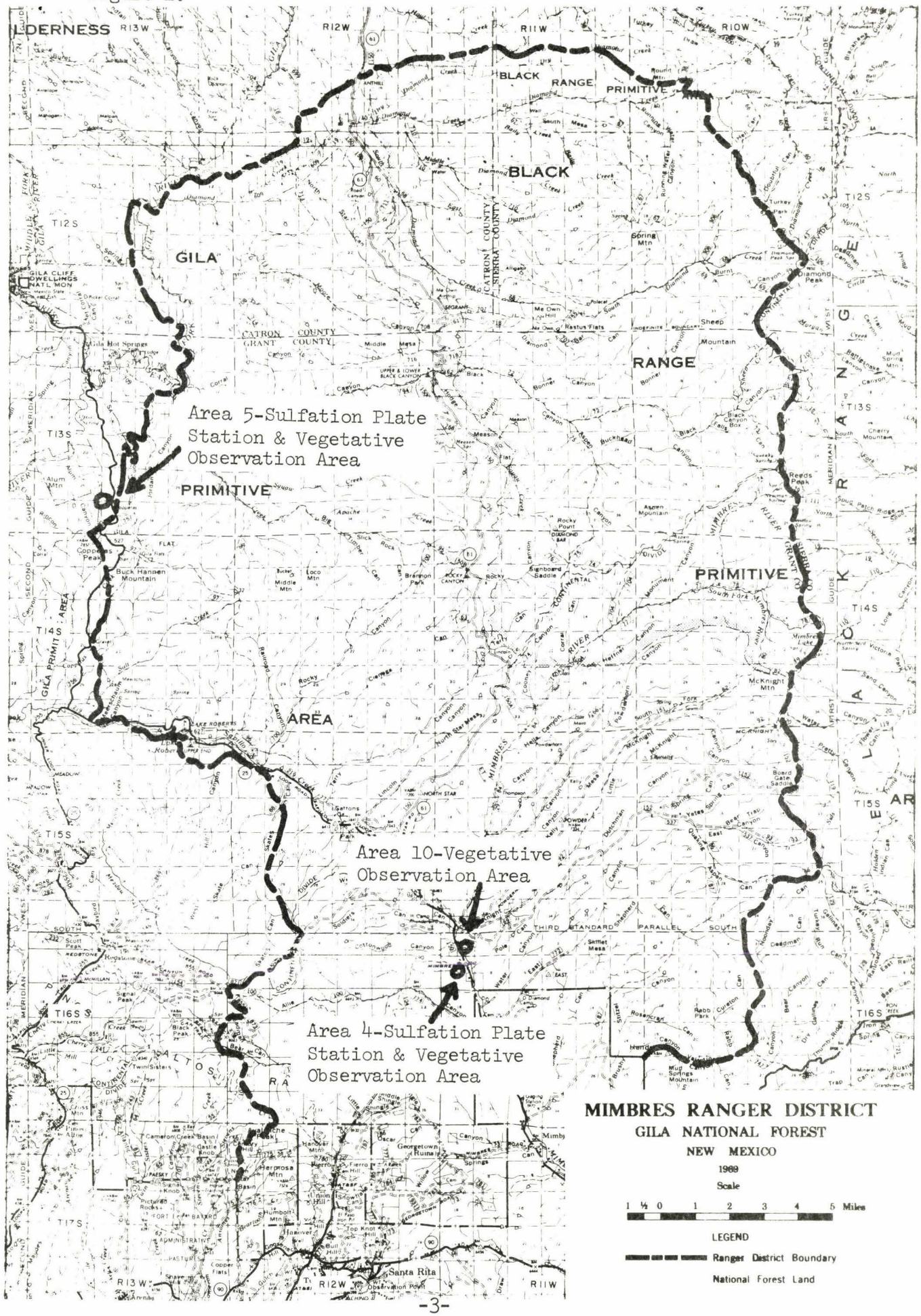
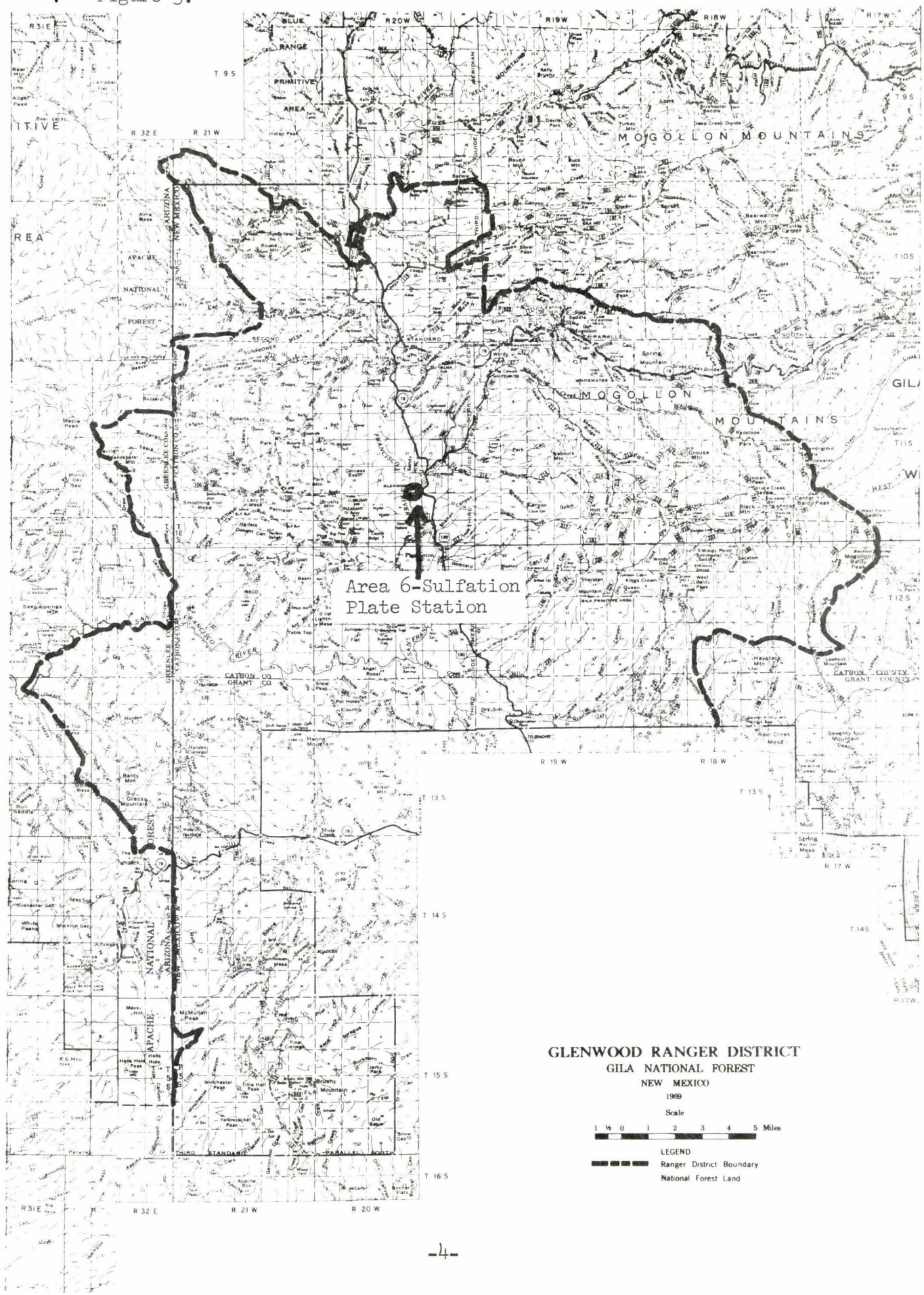

Area 5-Sulfation Plate Station & Vegetative Observation Area
Area 10-Vegetative Observation Area
Area 4-Sulfation Plate Station & Vegetative Observation Area
BLACK RANGE PRIMITIVE AREA
GILA PRIMITIVE AREA
MIMBRES RANGER DISTRICT
GILA NATIONAL FOREST
NEW MEXICO
1989
Scale
1 ½ 0 1 2 3 4 5 Miles
LEGEND
Ranger District Boundary
National Forest Land

Figure 3.


Area 6-Sulfation
Plate Station
GLENWOOD RANGER DISTRICT
GILA NATIONAL FOREST
NEW MEXICO
1969
Scale
1 ¼ 0 1 2 3 4 5 Miles
LEGEND
Ranger District Boundary
National Forest Land

is to determine if similar injury has occurred to a variety of plant species.1/

2. The observation areas should have adequate soil moisture. Plants growing in areas with adequate soil moisture and high humidity are more susceptible to SO_2 injury than plants growing under arid conditions.1/

The foliage of trees and associated plants was examined for the interveinal bleaching, interveinal necrosis, and tip burn typical of acute SO_2 injury. In addition, leaf and needle abnormalities from other causes were noted for future reference.

Results.--The following plant species were examined for evidence of acute SO_2 injury:

Forest Trees

Ponderosa pine (Pinus ponderosa)
Southwestern white pine (Pinus strobiformis)
Pinyon pine (Pinus edulis)
Chihuahua pine (Pinus leiophylla var. chihuahuana)
Arizona walnut (Juglans major)
Cottonwood (Populus spp.)
Willow (Salix spp.)
Box elder (Acer negundo var. interius)
Wild cherry (Prunus spp.)
Grey oak (Quercus grisea)
Gambel oak (Quercus gambelii)
One-seed juniper (Juniperus monosperma)
Alligator juniper (Juniperus deppeana)
Arizona alder (Alnus oblongifolia)
Elm (Ulmus spp.)

Forest Plants and Shrubs

Wright silktassel (Garrya wrightii)
Mountain mahogany (Cercocarpus spp.)
Fendlerbush (Fendlera rupicola)
Skunkbush (Rhus trilobata)
Sunflower (Helianthus spp.)
Brickellbush (Brickellia spp.)
Wild grape (Vitis spp.)

1/ Air Pollution Control Assoc. 1970. Recognition of Air Pollution Injury to Vegetation: A Pictorial Atlas. Jacobson, J. S., and A. C. Hill, Editors. Pittsburgh, Pa.

No symptoms of acute SO_2 injury were found on trees and plants in any of the areas which were examined. Tree and plant condition was noted as follows:

1. Marginal necrosis (Figure 4) was evident on the foliage of Wright silktassel in Area 1 (Figure 1). This symptom is probably caused by heat or drought stress. The foliage of other trees and plants in the area appeared normal. Ponderosa pine foliage, on trees examined approximately 1 mile from Area 1, has a needle mottle or fleck of unknown cause on the older needles. This marking was beginning to show on some of the current year's needles. These trees retained 2-3 years' foliage.

2. Several cottonwood trees growing on the Fort Bayard hospital grounds, located approximately 1.5 miles south of Area 9 (Figure 1), had chlorotic foliage (Figure 4). Other trees and plants examined in the area appeared to have normal foliage.

3. Several willow and Arizona alder trees, located in Area 7 (Figure 1), had chlorotic foliage (Figure 5). Ponderosa pine in this area had a needle mottle or fleck on the older needles. These trees retained 2-3 years' needle growth.

Sulfation plate data for the period October 1970-October 1971 are as follows:

Area 1 - Silver City Ranger District

Month	Days exposed	* Sulfation rate (Micrograms $SO_3/cm^2/day$)
Oct. 1970	33	3.2
Nov.	27	3.2
Dec.	35	3.6
Jan. 1971	24	7.3
Feb.	31	2.2
Mar.	31	5.8
Apr.	32	5.0
May	25	** <Detectable minimum
Jun.	40	3.6
Jul.	--	--
Aug.	33	1.4
Sep.	31	<Detectable minimum
Oct.	27	<Detectable minimum

* Corning Laboratories, Inc., Cedar Falls, Iowa, supplies and analyzes all sulfation plates.

** Detectable minimum for 30-day period (micrograms $SO_3/cm^2/day$) Sep. 1970-Mar. 1971 - 1.2; Apr. 1971-Sep. 1971 - 1.0; Oct. 1971 - 0.8

Figure 4.

Drought or heat injury to Wright silktassel, Area 1, Silver City Ranger District.

Chlorotic foliage on cottonwood, Fort Bayard hospital.

Figure 5.

Chlorotic foliage on willow, Area 7, Silver City Ranger District.

Chlorotic foliage on Arizona alder, Area 7, Silver City Ranger District

Area 1A - Silver City Ranger District

Month	Days exposed	* Sulfation rate (Micrograms $SO_3/cm^2/day$)
Jun. 1971	40	3.9
Jul.	--	--
Aug.	33	1.4
Sep.	31	1.3
Oct.	27	1.5

Area 2 - Silver City Ranger District

Oct. 1970	34	4.4
Nov.	26	5.4
Dec.	35	1.7
Jan. 1971	24	2.4
Feb.	31	2.1
Mar.	31	2.8
Apr.	32	4.0
May	31	** <Detectable minimum
Jun.	34	<Detectable minimum
Jul.	--	--
Aug.	30	4.4
Sep.	31	2.6
Oct.	27	1.5

Area 3 - Silver City Ranger District

Oct. 1970	27	<Detectable minimum
Nov.	27	<Detectable minimum
Dec.	43	3.8
Jan. 1971	16	<Detectable minimum
Feb.	32	3.4
Mar.	30	6.0
Apr.	31	4.5
May	32	1.8
Jun.	34	6.5
Jul.	--	--
Aug.	33	<Detectable minimum
Sep.	31	1.3
Oct.	27	<Detectable minimum

* Corning Laboratories, Inc., Cedar Falls, Iowa, supplies and analyzes all sulfation plates.

** Detectable minimum for 30-day period (micrograms $SO_3/cm^2/day$)
Sep. 1970-Mar. 1971 - 1.2
Apr. 1971-Sep. 1971 - 1.0
Oct. 1971 - 0.8

Area 4 - Mimbres Ranger District

Month	Days exposed	* Sulfation rate (Micrograms $SO_3/cm^2/day$)
Nov. 1970	16	** <Detectable minimum
Dec.	30	1.5
Jan. 1971	31	1.9
Feb.	28	2.1
Mar.	31	4.1
Apr.	--	--
May	31	<Detectable minimum
Jun.	30	<Detectable minimum
Jul.	31	<Detectable minimum
Aug.	31	<Detectable minimum
Sep.	30	<Detectable minimum
Oct.	30	<Detectable minimum

Area 5 - Wilderness Ranger District

Oct. 1970	16	4.0
Nov.	26	2.9
Dec.	30	1.9
Jan. 1971	--	--
Feb.	23	<Detectable minimum
Mar.	35	3.6
Apr.	33	3.2
May	28	1.4
Jun.	37	1.1
Jul.	23	2.0
Aug.	45	<Detectable minimum
Sep.	16	<Detectable minimum

Area 6 - Glenwood Ranger District

May 1971	32	1.3
Jun.	30	1.2
Jul.	31	<Detectable minimum
Aug.	31	<Detectable minimum
Sep.	30	<Detectable minimum
Oct.	31	<Detectable minimum

* Corning Laboratories, Inc., Cedar Falls, Iowa, supplies and analyzes all sulfation plates.

** Detectable minimum for 30-day period (micrograms $SO_3/cm^2/day$)
Sep. 1970-Mar. 1971 - 1.2
Apr. 1971-Sep. 1971 - 1.0
Oct. 1971 - 0.8

Discussion.--Diagnosis of air pollution injury to vegetation is complicated by environmental, insect, and other disease factors. These factors can cause leaf and plant symptoms which appear similar to symptoms of air pollution injury. In addition, the occurrence or severity of air pollution-caused plant injury is determined not only by the pollutant concentrations and duration of exposure, but by many environmental factors which can affect individual plant sensitivity. These factors include light, moisture, temperature, and nutrient relations.2/ To date, the only places we have found symptoms of acute SO_2 injury to Southwestern forest vegetation have been within 4 miles of the source emitting SO_2. Therefore, the lack of acute damage symptoms might be expected because all areas, except Area 9, are more than 11 miles from the smelter. Area 9 is approximately 8 miles from the smelter. Our investigations; the investigations reported by Dr. Howard J. Dittmer, Professor of Biology at the University of New Mexico;3/ and those by Dr. Walter W. Heck, plant physiologist in the Crops Research Division, ARS, USDA (W. W. Heck, unpublished Southwest Trip Report); indicate that acute injury to vegetation, caused by SO_2 in smelter emissions, has not been found on the Gila National Forest.

There appears to be disagreement, however, on whether or not chronic injury to forest vegetation has occurred, or is occurring. On one hand, Dr. Heck observed that willows in Area 7 showed a classic chlorotic mottle pattern which has been associated with SO_2 in the East. He thought that this pattern suggested three or more fumigations of a non-acute type (W. W. Heck, unpublished Southwest Trip Report). On the other hand, Dr. Dittmer stated at the air quality hearings in Santa Fe, New Mexico, that he had "found no evidence of SO_2 toxicity or particulate damage on any of the indigenous open range plants or on 10 out of the 11 mountain species. The single exception was about a half-dozen Chinese elms very close to the smelter, within a quarter of a mile, to the northeast." Dr. Dittmer further testified that "in most sections of New Mexico, chlorosis is common in many species due to a low availability of iron. In my (Dr. Dittmer's) judgment, this condition is caused by generally alkaline soil conditions." Dr. Dittmer continued his testimony by noting that "in contrast, plants in the Hurley area are remarkably free of chlorosis," and that "occasional fumigations of acidic gases from the smelter stacks when combined with moisture in the soil may have tended over the years to lower the pH of the soil around Hurley and thus to make available iron more soluble for plant root absorption. Further soil surveys are planned to verify this hypothesis." Dr. Dittmer concluded by saying that "if it (the above) is true, on balance the effect of SO_2 emissions from the Hurley smelter may be said to have been beneficial to vegetation in that area."3/

2/ Treshow, M. 1970. Environment and Plant Response. McGraw-Hill Book Co., N.Y. 422 p.

3/ Proceedings, Proposed Air Quality Control Standards. 1971. Vol. 1, p. 131-135. Santa Fe, N.M.

The next step in attempting to determine whether or not chronic SO_2 injury is occurring to forest vegetation would be to note if the chlorosis problem reported in Area 7 occurs again in the summer of 1972. If leaf chlorosis develops, a foliar application of a dilute solution of an iron chelate micronutrient would help confirm whether or not the chlorosis is caused by an iron deficiency.4/ If the chlorotic symptoms disappear, iron deficiency is probably the cause. If the chlorotic symptoms persist, other causal factors must be considered.

The needle mottle or fleck on ponderosa pine, noted in Area 7 and near Area 1, has been found in New Mexico and Arizona for many years. This needle marking can be found in areas far from any known sources of air pollution, as well as areas close to industrial activity. We are now attempting to determine if the appearance of this marking is related to a particular time of year. In addition, we are working with Forest Service research plant pathologists, and members of the University of Arizona Department of Plant Pathology, in trying to determine the cause of this needle marking.

Sulfation plates are being used to determine if SO_2 and other sulfur compounds are reaching the vegetative observation areas.5/ The sulfation plates are exposed for approximately 30 days, during which time sulfur compounds react with the lead dioxide in the plate. The product of these reactants is then measured and expressed as micrograms $SO_3/cm^2/day$.6/ This is commonly called the sulfation rate. To date, no relationship has been noted between sulfation rate and the presence of plant injury. Comparisons have not been possible because most of the acute plant injury we have found has not been in the vicinity of our sulfation plate stations. These plates provide an economical way of determining the general dispersion of total sulfur compounds, and, therefore, may prove useful in finding locations more susceptible to SO_2 injury. Eventually, it may be possible to develop an area plant hazard rating system based on monthly average sulfation rates and relative susceptibility of native forest species.

4/ Wallace, T. 1961. Mineral Deficiencies in Plants. Chemical Publishing Co., Inc., New York. 2nd Edition.
5/ Tucson Advisory Committee on Air Pollution. 1971. Air Pollution in Tucson: A Report to the Mayor and Council of the City of Tucson. Edited by R. Caldwell. 141 p.
6/ Huey, N. A. 1968. The Lead Dioxide Estimation of Sulfur Dioxide Pollution. J. Air Poll. Control Assoc. 18: 9.

In order to get some idea of sulfation plate reliability, duplicate plates were exposed in Area 1 (Areas 1 & 1A) and in five other locations in Arizona. The sulfation rates of several individual plate-pairs varied considerably; however, when all plate-pairs are considered, there is a highly significant correlation between the sulfation rates on each of the plate-pairs ($R = 0.859$ with 26 degrees of freedom). There is no significant difference between the average of the means of each set of plate-pairs ($T = 1.03$ with 26 degrees of freedom).

A map is attached which shows the areas included in the 1971 air pollution detection survey.

Recommendations.--

1. Examine selected areas of the Gila National Forest, in the late summer of 1972, for evidence of acute or chronic injury caused by SO_2.

2. Re-examine Area 7 to see if chlorotic symptoms develop on vegetation in that area. If these symptoms develop, apply a dilute solution of an iron chelate micronutrient to the affected foliage.

3. Continue the present sulfation plate network at least until November 1972. More information is needed concerning sulfation rate and the presence or absence of plant injury.

AIR POLLUTION DETECTION SURVEY - 1971
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